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BATHYMETRY AND BOTTOM STRUCTURE OF ZONES NEAR THE ISLAND OF ELBA USED FOR ACOUSTICAL TRIALS IN SHALLOW WATER

by

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15 December 1970

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Director

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ABSTRACT

Two shallow-water zones situated north and south-east of the Island of Elba have been surveyed to obtain information about the bottom conditions. The area to the north of the island has a depth of 100 m to 130 m and a very flat bottom covered with clay and sand-clay sediments. The area to the south-east of the island is of the same depth and has a flat bottom covered with clay sediments. In this area a very strong acoustic reflector exists under the sedimentary layer.

INTRODUCTION

Sound propagation in shallow water depends on the velocity structure of the water, where the sound is refracted by gradients, and on the environmental characteristics of the boundaries, where the sound is reflected and scattered. At moderate sea states, when surface effects are of less importance, the reflection characteristics of the bottom stand out as the most important factor that determines propagation losses and reverberation levels.

A considerable effort has been put into environmental studies in order to be able to make controlled experiments and compare the results with theoretical predictions. About 1200 km of echo-soundings, 6 cores, and bottom photographs obtaine at 14 different stations have been compiled to describe the bottom conditions of the zones north and south-east of the Island of Elba that SACLANTCEN is using for shallow-water acoustical trials.

This study presents the information about the bottom conditions obtained during five cruises.

1. THE NORTH ELBA ZONE

1.1 General

The zone is situated between latitudes 42° 46'N and 43° 27'N, and longitudes 09°49'E and 10° 33'E. The echo-sounding tracks, the positions of the cores, and the photographic stations are shown in Fig. 1.

1.2 Bathymetry

The 730 km of echo-soundings obtained were used to construct the bathymetric chart of the trial zone shown in Fig. 2. Soundings from the peripheral areas shown in this figure (the regions between the Italian mainland and the Island of Capraia, and from Elba to the Island of Gorgona) were taken from Refs. 1 and 2.

In the eastern part of the zone the bottom deepens continuously westwards, as far as the 100 m isobath. Between the 100 m and 130 m isobaths there is a flat bottom that extends over an area of 60 km north-south and 20 km east-west in which the slope is only 0.1° to 0.2°.

In the western part of this flat region the bottom deepens continuously towards the axis of a V-shaped submarine valley [Fig. 3] that runs in a relatively straight line from north-west to south-east diagonal to the trend of the north coast of Elba. This valley extends from near the shore, at a depth of about 100 m, to a small bowl-shaped 680 m deep basin situated a short distance beyond the limits of the bathymetric chart.

1.3 Cores

The sedimentologic investigation of the N.Elba zone has so far consisted of the analysis of four cores taken with the SACLANTCEN sphincter corer [Refs. 3 and 4]. The only analysis of three of cores (Core Nos. 116, 117 and 118) was of water content and

porosity; the mass-physical properties of Core No. 119 were analysed in detail [Ref. 5]. The measured porosity and types of sediment of these cores are presented in Fig. 4 [Ref. 6].

Core No. 116

This 190 cm long core was taken from the northern part of the zone and was analysed for water content and porosity. It contains an upper 90 cm of clay in which the porosity decreases from 74% to 50% where it overlies the sand layer.

Core No. 117

This 410 cm long core was taken from the centre of the surveyed zone and consists of clay with two thin layers of sand and shell. It displays the same general characteristic in the upper clay layers (which is here 65 cm thick) as did Core No. 116, the porosity of 75% decreasing with depth to 50%.

Core No. 118

This 345 cm long core was taken 3 km south of Core No. 117 and shows different characteristics. The 160 cm thick top layer contains a layer of sand mixed with shells and organic debris in which the porosity varies between 65% and 40%. The underlying layer consists of clay with a constant porosity of 53%.

Core No. 119

This 395 cm long core was taken from the southern part of the zone. Figure 5 represents the measured porosities, relative densities and relative sound velocities of the samples according to their depth [Ref. 4]. This core also contains a top layer of sand and organic debris, although its thickness (35 cm) is less than that in Core No. 118. Below this upper layer there is a 255 cm thick clay layer followed by a thin layer of organic debris and then a sand layer with shells and organic debris. Below these is a 20 cm thick layer that is a mixture of mud and sand.

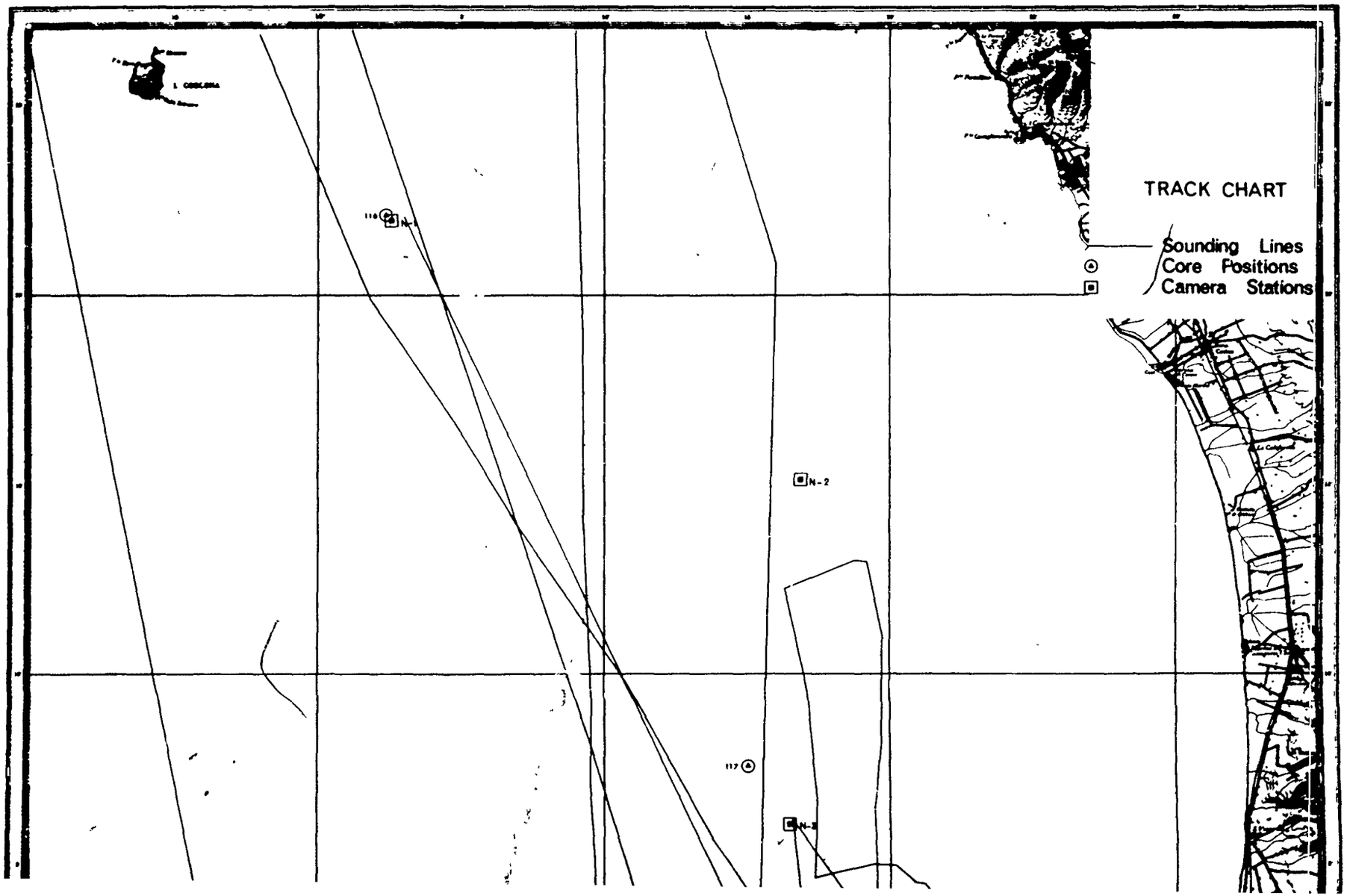
These four cores reveal two different lithologies in the sediments of the bottom. The cores taken in the northern part of the zone (Core Nos. 116 and 117) indicate an upper layer of highly porous

clays; those taken in the southern part (Core Nos. 118 and 119) indicate sand in the upper layer.

1.4 Bottom Photography

Over 40 photographs were obtained at each of the five locations marked in Fig. 1.

All the photographs [Fig. 6] show a flat bottom with numerous burrows and some tracks, denoting animal activity on the bottom.


TRACK CHART
Sounding Lines
Core Positions
Camera Stations
N-1
N-2
N-3
117

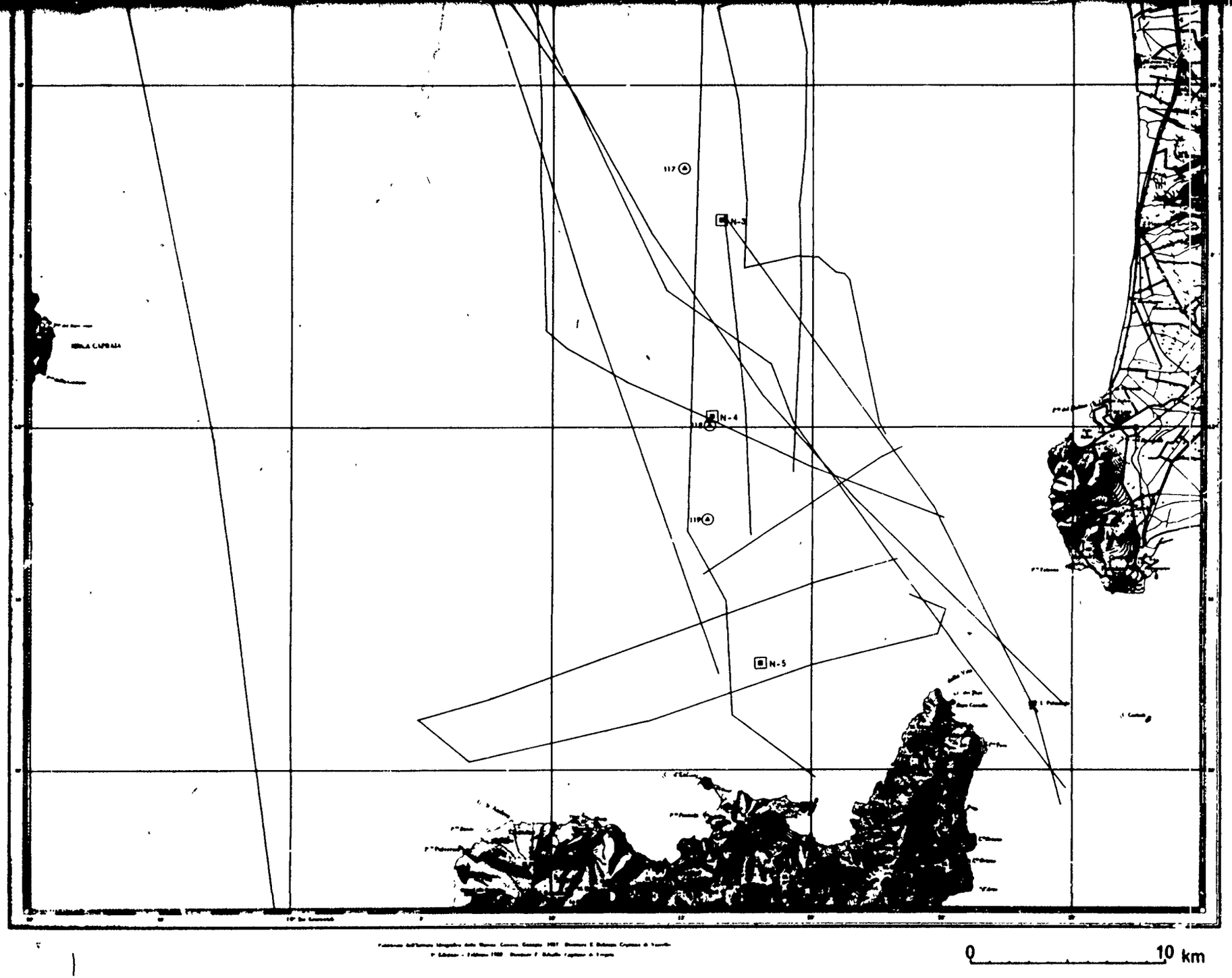
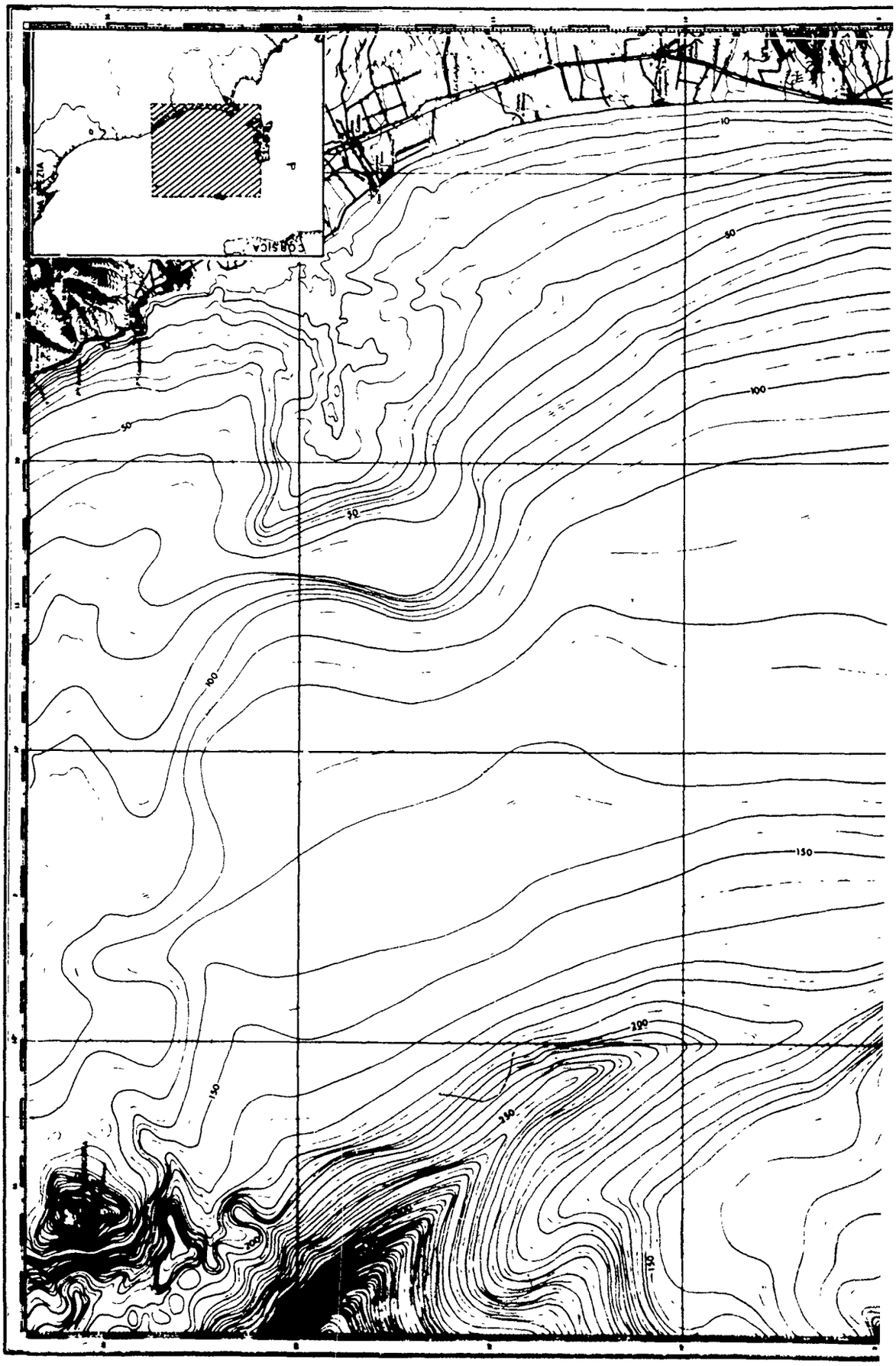


FIG. 1 TRACK CHART, CORE AND PHOTOGRAPHIC STATIONS IN THE NORTH ELBA ZONE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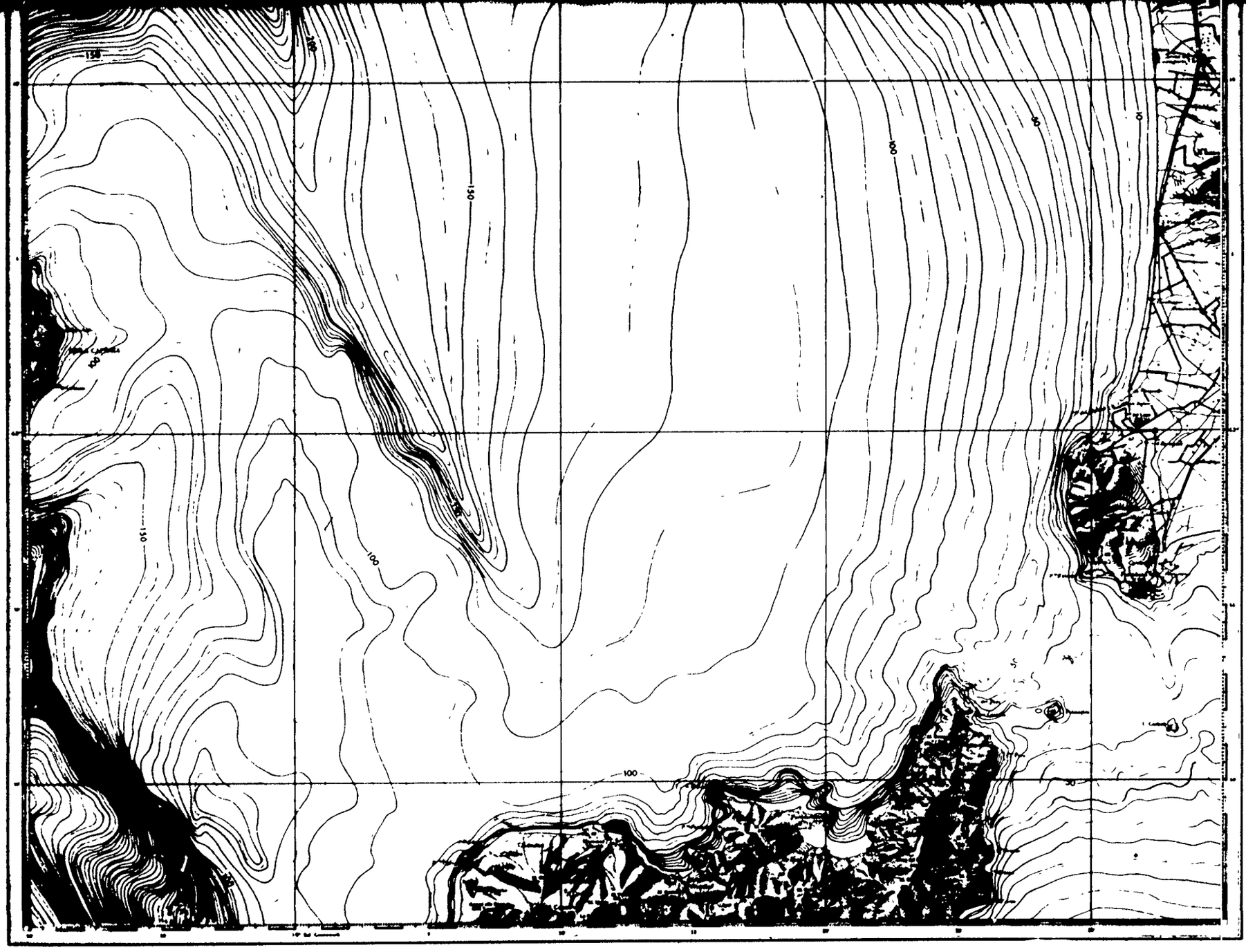

FIG. 2 BATHYMETRIC CHART OF THE NORTH ELBA ZONE

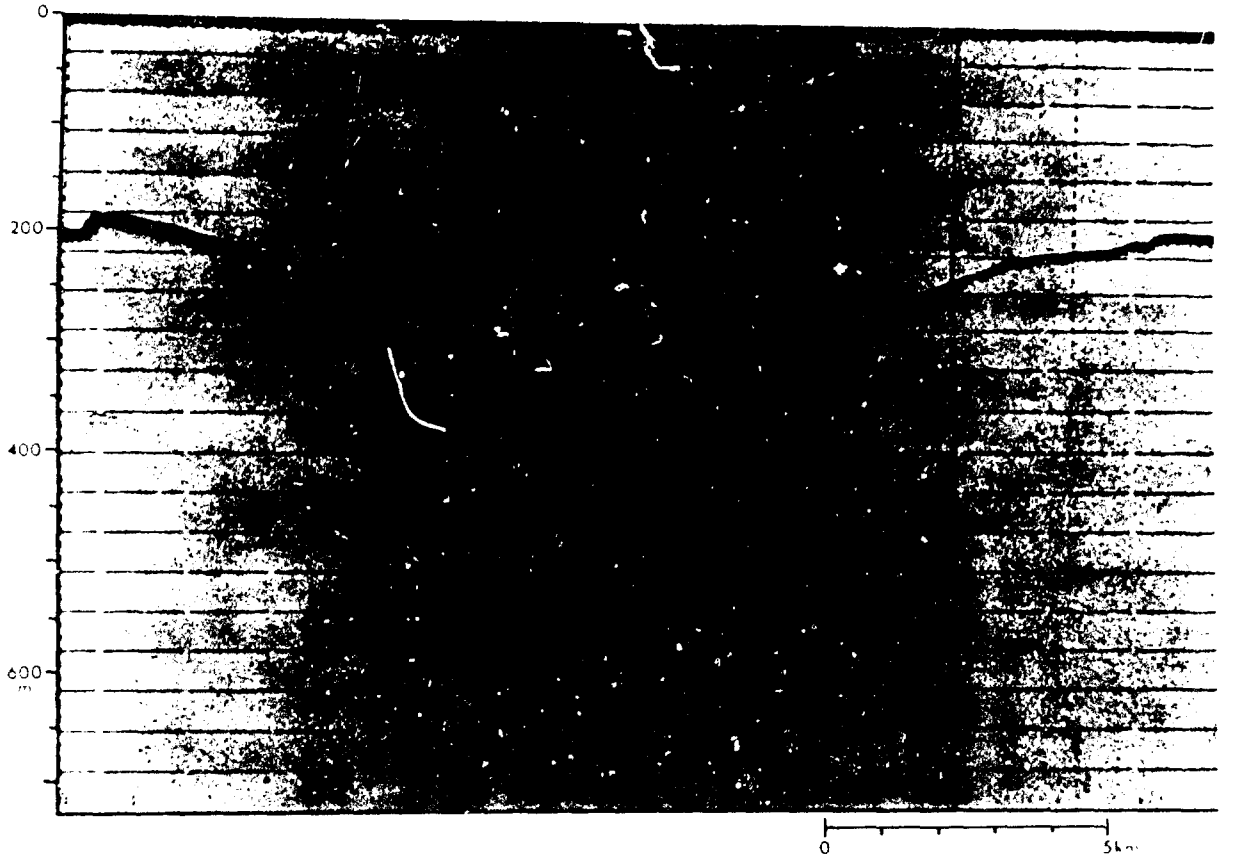

FIG. 3 SAMPLE PFR PROFILE OBTAINED OVER SUBMARINE VALLEY IN THE NORTH ELBA ZONE

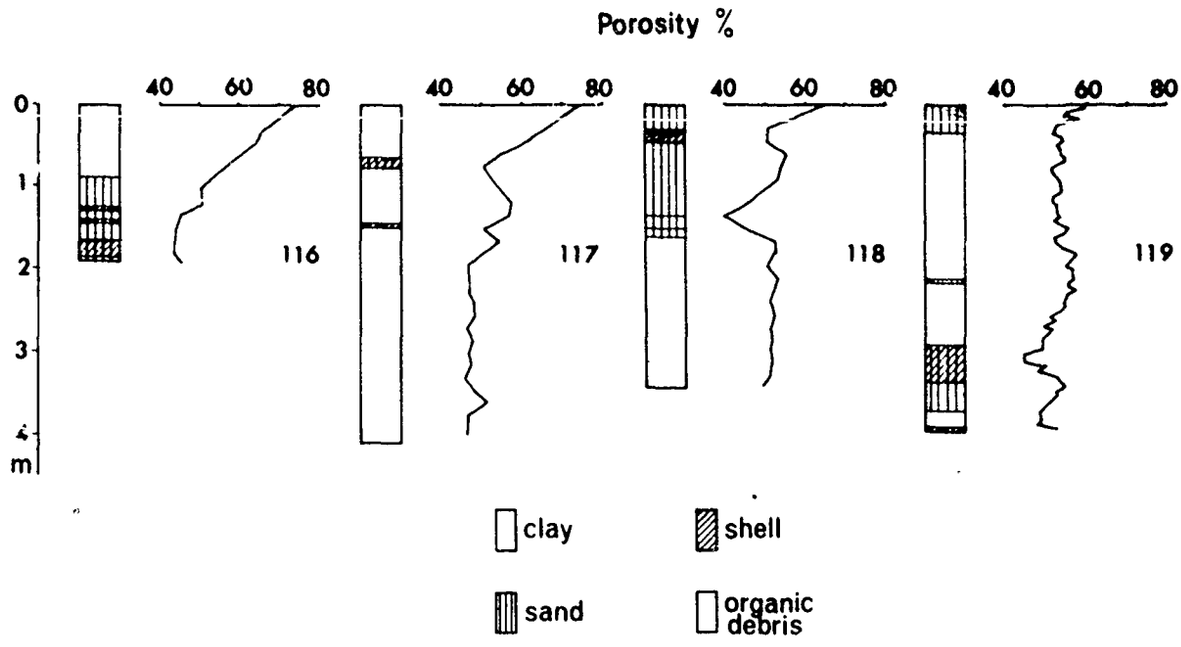

FIG. 4 POROSITIES AND SEDIMENT TYPES OF THE CORES IN THE NORTH ELBA ZONE

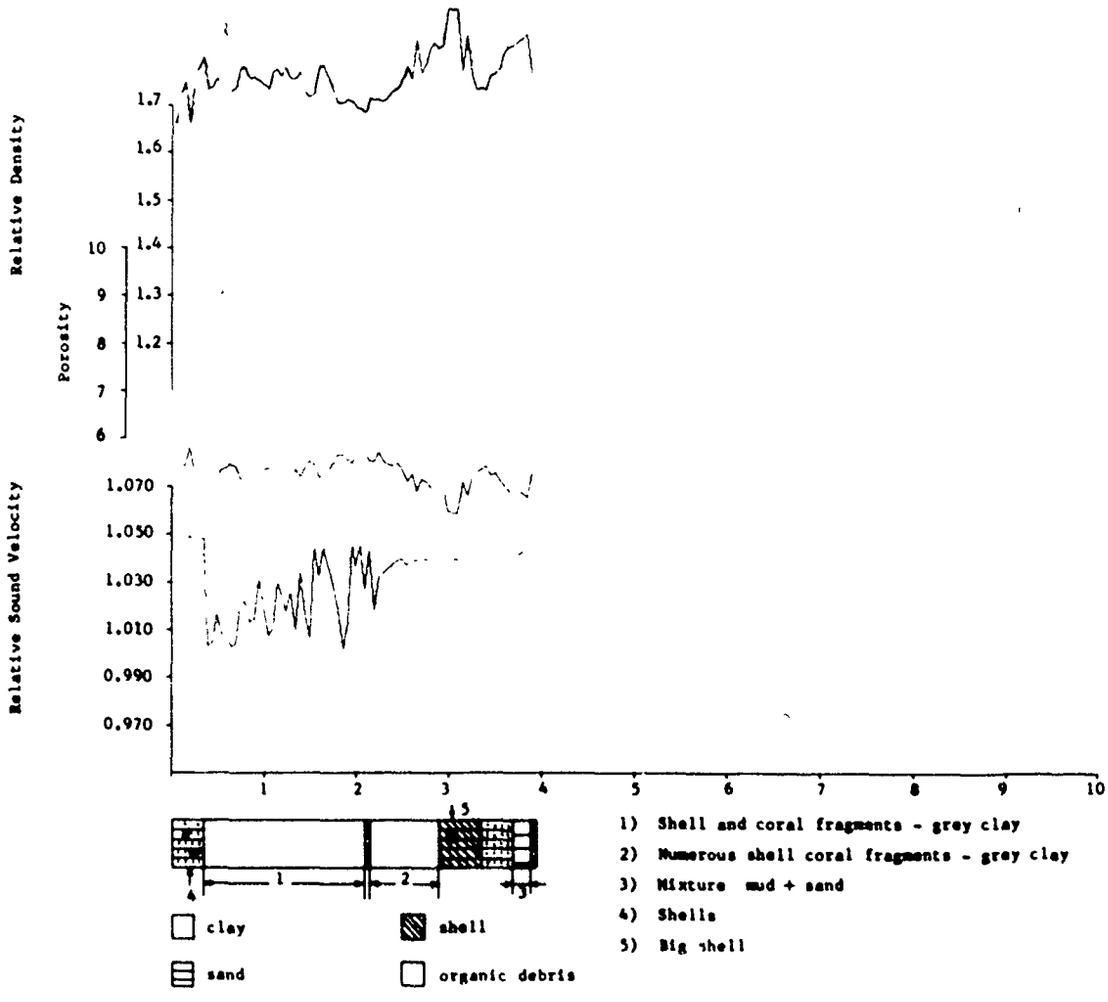

FIG. 5 POROSITY, RELATIVE DENSITY AND RELATIVE SOUND VELOCITY IN CORE 119

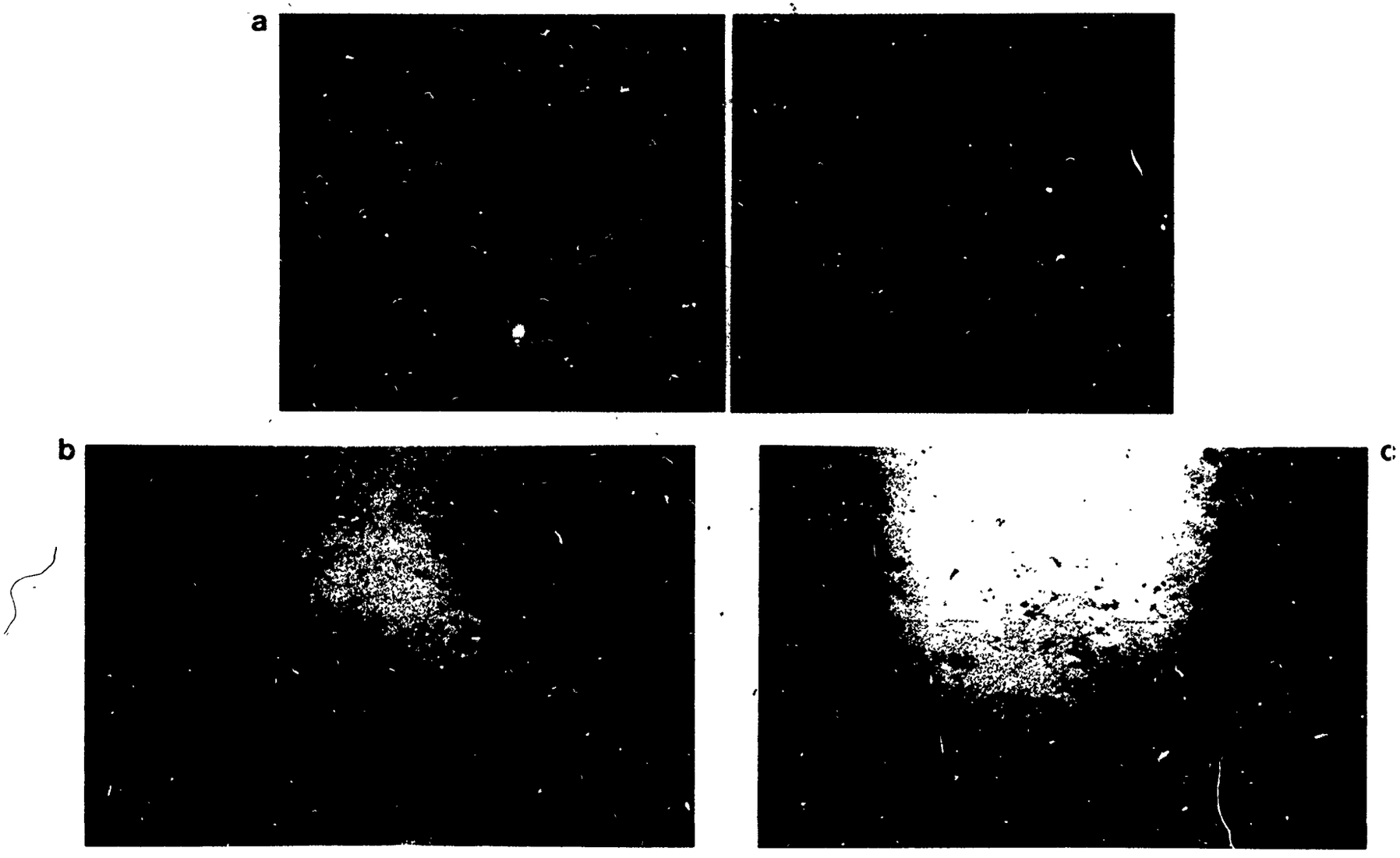

FIG 6 BOTTOM PHOTOGRAPHS FROM THE NORTH ELBA ZONE

(a) Stereo-pair from station N3 showing very flat bottom with numerous burrows

(b) & (c) Characteristic photographs from the zone (burrows are approximately 2 cm diam.)

2. THE SOUTH-EAST ELBA ZONE

2.1 General

This zone is situated between latitudes 42° 32'N and 42° 54', and longitudes 10°23'E and 11° 02'E. The echo-sounding tracks, positions of the cores and photographic stations are shown in Fig. 7.

2.2 Bathymetry

The bathymetric chart of the trial zone shown in Fig. 8 was constructed from the data obtained from 470 km of echo-sounding tracks; soundings from the peripheral areas were taken from Refs. 2 and 7.

In the northern part of the zone the bottom deepens continuously southwards from the Piombino channel and Follonica Gulf to the 100 m isobath, where the flat bottom starts. In the north-eastern part of the zone the bottom deepens rapidly from the coastline to the 95 m isobath. From there the flat bottom slopes down to the 130 m isobath at 0.1° to 0.2° in a southerly direction. This flat bottom extends over an area of 30 km in an east-west direction and 10 km in a north-south direction.

The region between Elba and Formiche di Grosseto islands, where the flat bottom is very close to the shores of the islands [Figs. 9a and 9b], seems suitable for fixed installations. Such fixed installations could possibly be used to study the various aspects of sound propagation in shallow water and to obtain reliable statistical data over a long period in different oceanographic and meteorological conditions.

South of this flat region the bottom deepens southwards more rapidly.

2.3 Sub-bottom Reflectors

As seen in Fig. 10, there is a very strong acoustic reflector that generally has an irregular surface and appears to crop out towards Piombino channel but elsewhere is buried beneath the sedimentary layer. In some areas another reflector exists but this is mainly due to the physical changes in the sedimentary layer. This reflector shows a smooth surface, as seen in Fig. 11.

The strong reflector with the irregular surface is taken to be the basement rock. The thickness of the overlying sedimentary layer is shown in Fig. 12. In the northern part of the surveyed area the sedimentary layer is very thick [Fig. 13], which is probably due to the greater transporting power of the waves coming from the south towards the northeastern coastline. (This could also explain the much thinner layers in the deeper part of the zone.) As seen in Figs. 10 and 12, the thickness decreases westwards, possibly due to the currents coming through the channel.

2.4 Cores

Two cores were taken in this zone [Fig. 14], on one of which (Core No. 120) a mass-physical analysis was performed.

Core No. 120

This 385 cm long core was taken from the south-eastern part of the flat bottom area. The measured porosity, density and sound velocity are shown in Fig. 15. The upper part contains a 375 cm layer of clay with low sound velocity. Below this there is a layer that is a mixture of sand and organic debris, which is probably the smooth surface layer lying on top of the basement rock, as shown in Fig. 11.

Core No. 121

This core was taken from the north-western part of the zone. In this part various attempts were made to sample the strong reflecting horizon, but it was not possible to penetrate more

than 80 cm, owing to the existence of coarse and hard material that damaged the cutting edge of the corer. This core also contains a high-porosity clay layer in the upper part and a mixture of sand and organic debris in the lower part.

From the two cores taken in the south-east Elba zone [Fig. 14], the bottom is assumed to be covered with highly porous clays.

2.5 Bottom Photography

Photographs of the bottom were taken at nine locations [Fig. 16]. All the photographs obtained show a rather flat and soft bottom with numerous burrows and some tracks made by organisms.

The photographs taken on Stations 1 and 2 show that the bottom currents are active in this region so that the fine material has been moved and the characteristic smooth bottom with many burrows has been disturbed.

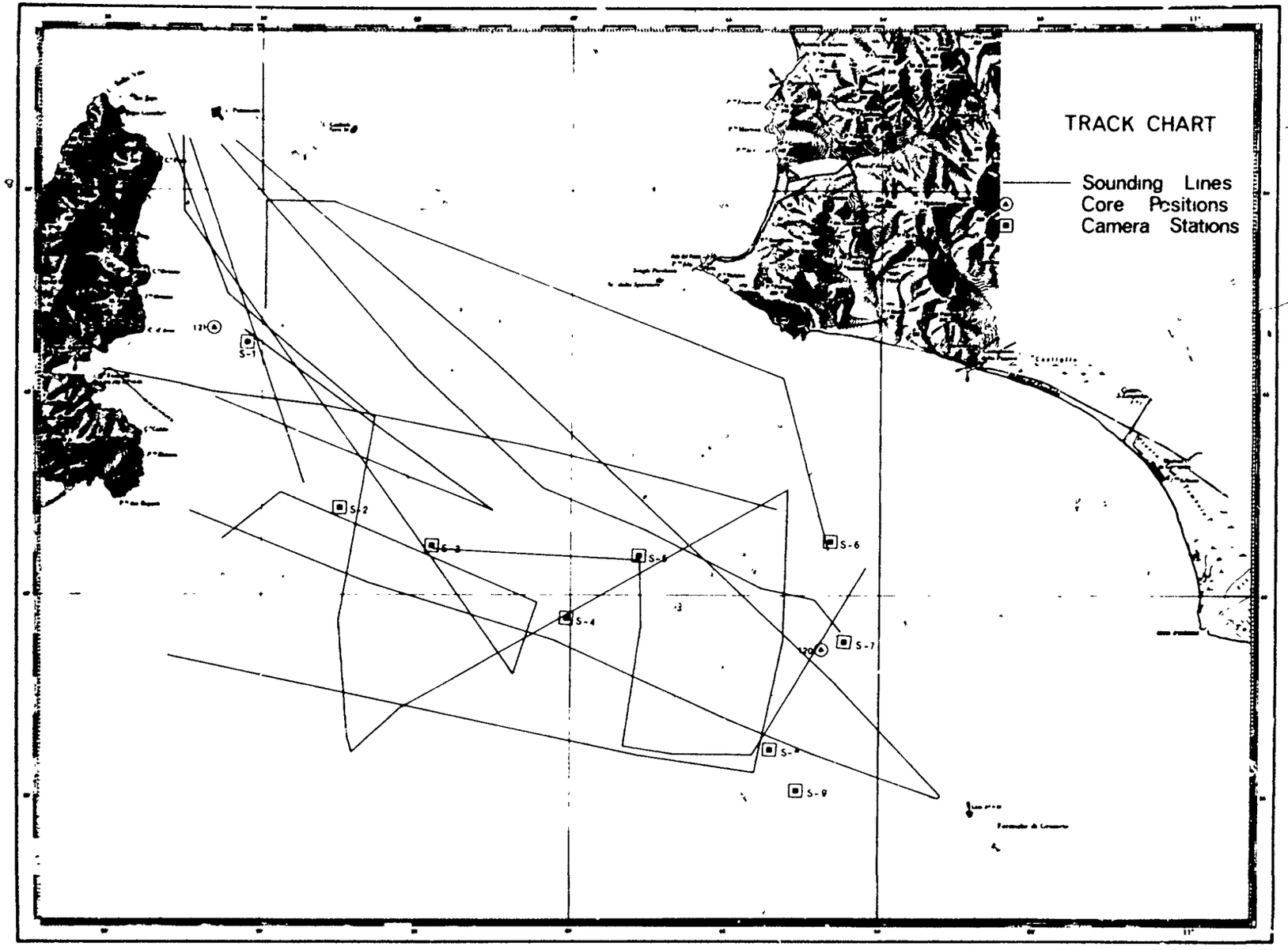

FIG. 7 TRACK CHART, CORE AND PHOTOGRAPHIC STATIONS IN THE SOUTHEAST ELBA ZONE

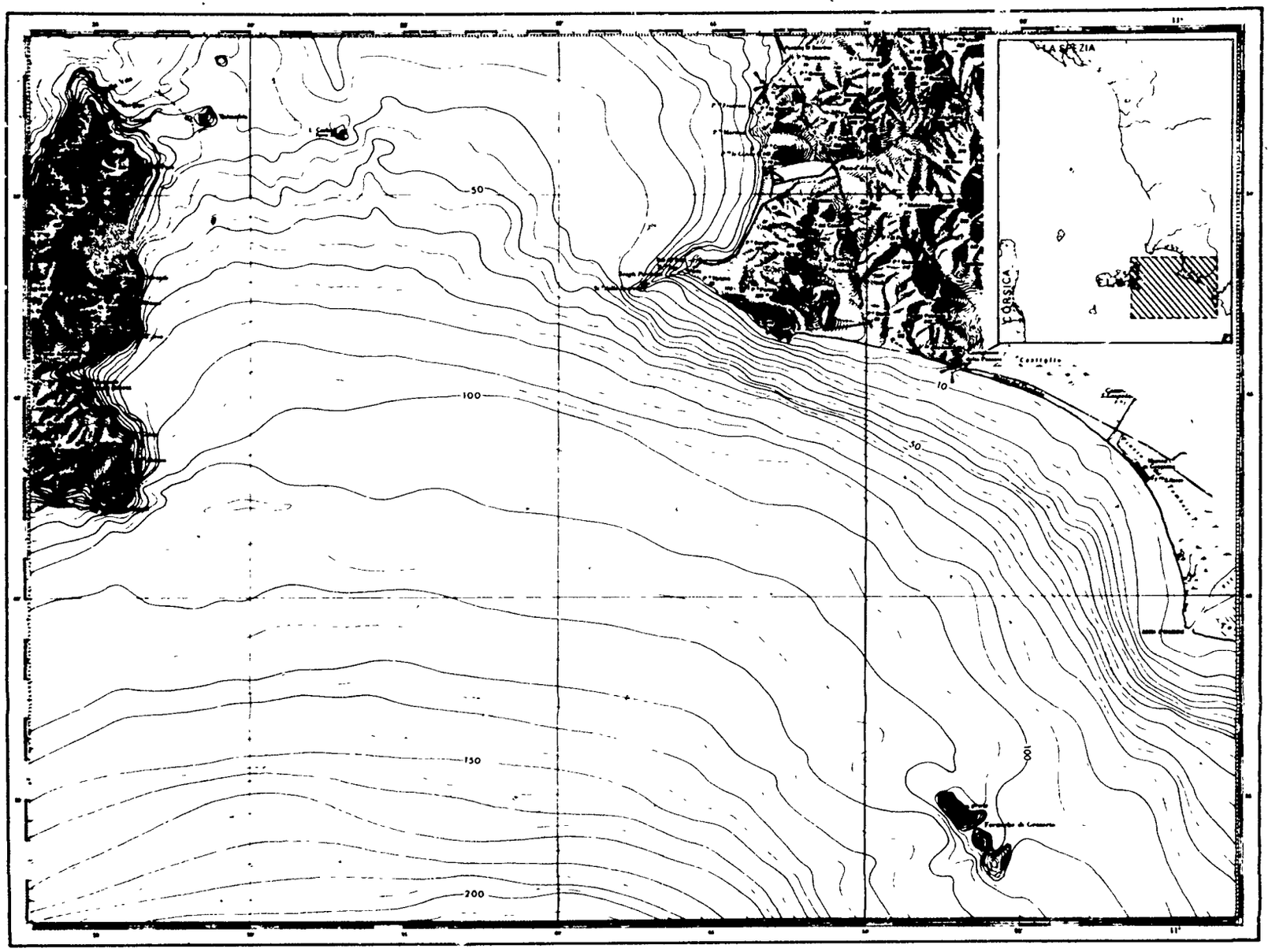

FIG. 8 BATHYMETRIC CHART OF THE SOUTHEAST ELBA ZONE

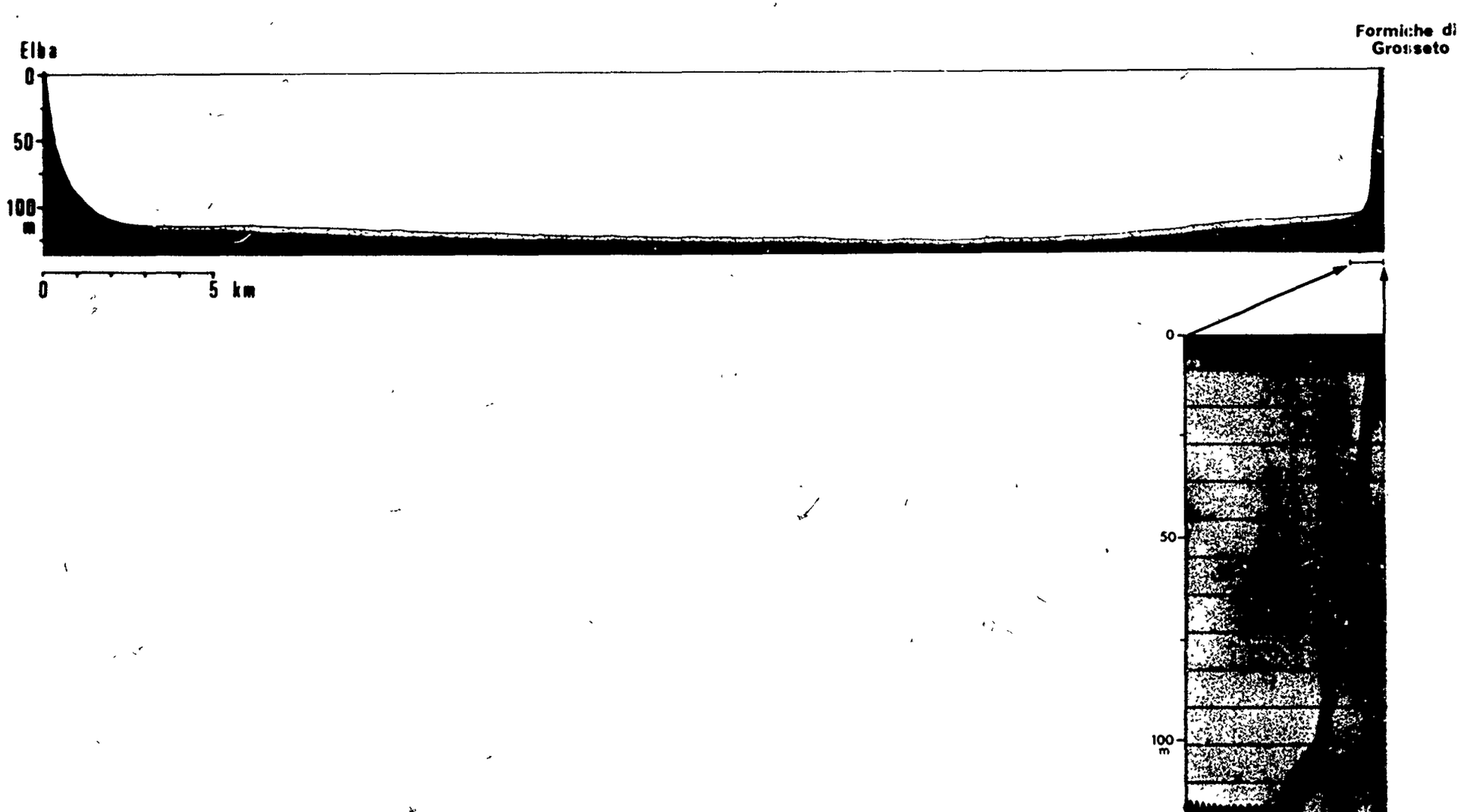

FIG. 9 BOTTOM AND SUB-BOTTOM PROFILE OBTAINED BETWEEN ELBA AND FORMICHE DI GROSSETO ISLANDS

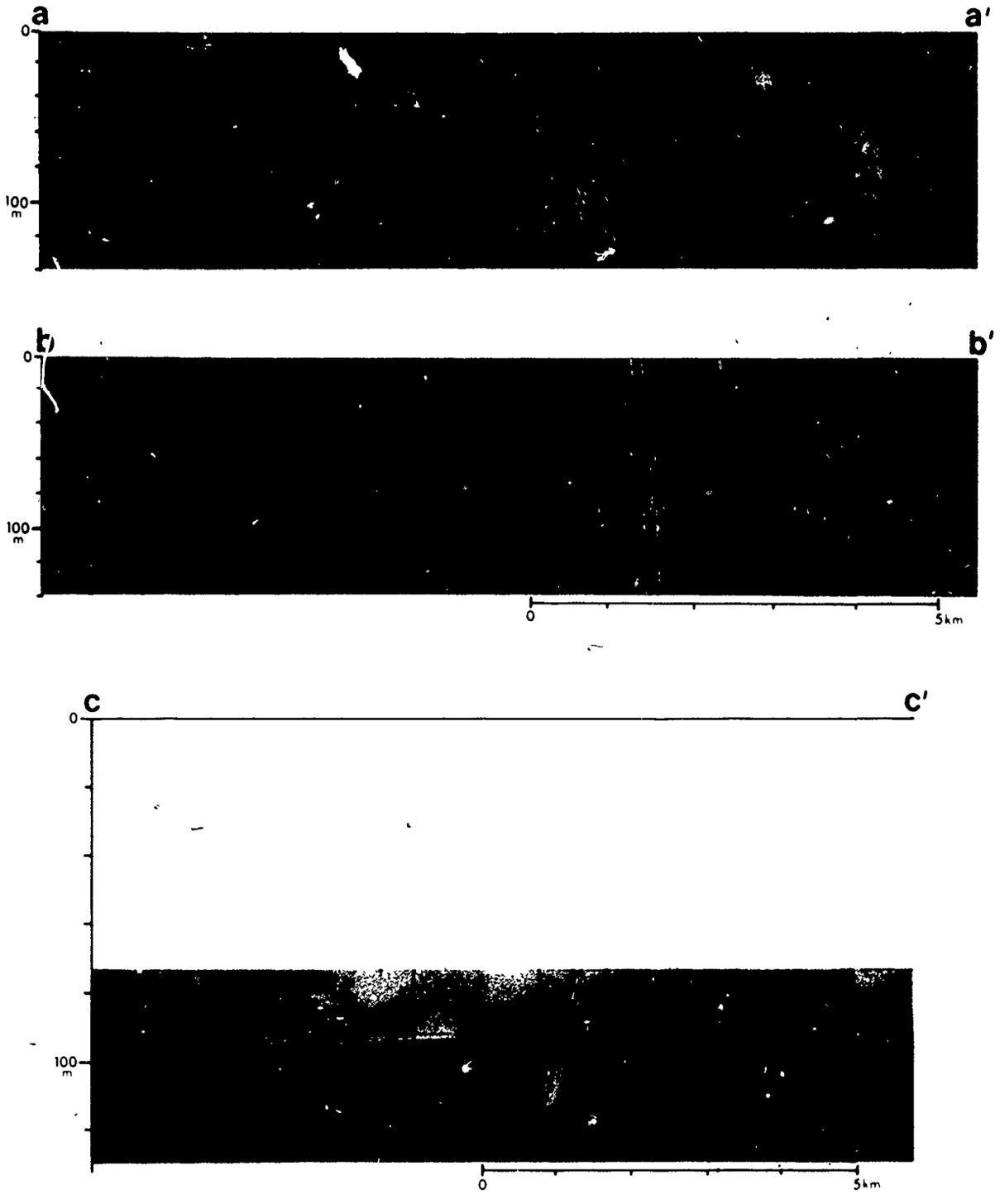

FIG. 10 SAMPLES OF PFR AND PGR PROFILES OBTAINED IN THE SOUTHEAST ELBA ZONE

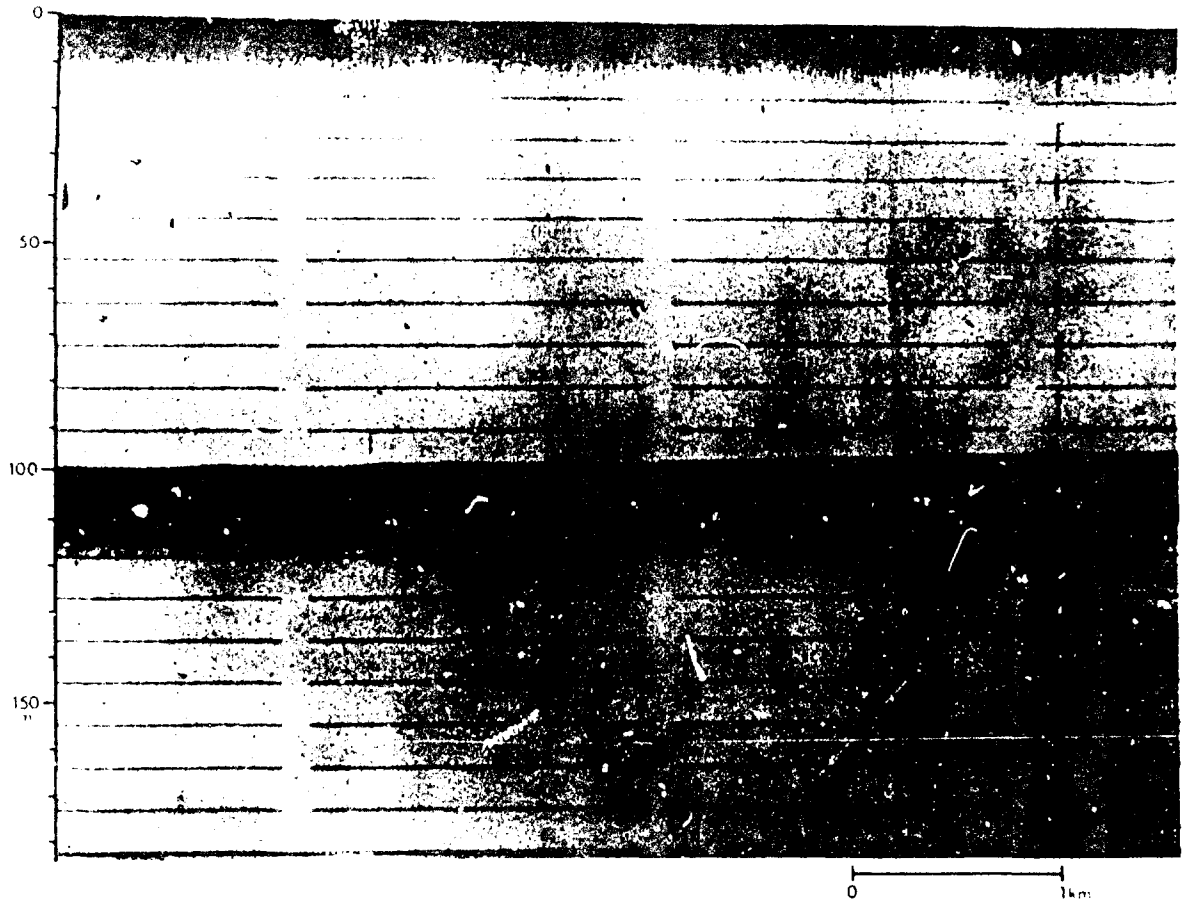

FIG. 11 THE SUB-BOTTOM REFLECTORS OF THE SOUTHEAST ELBA ZONE

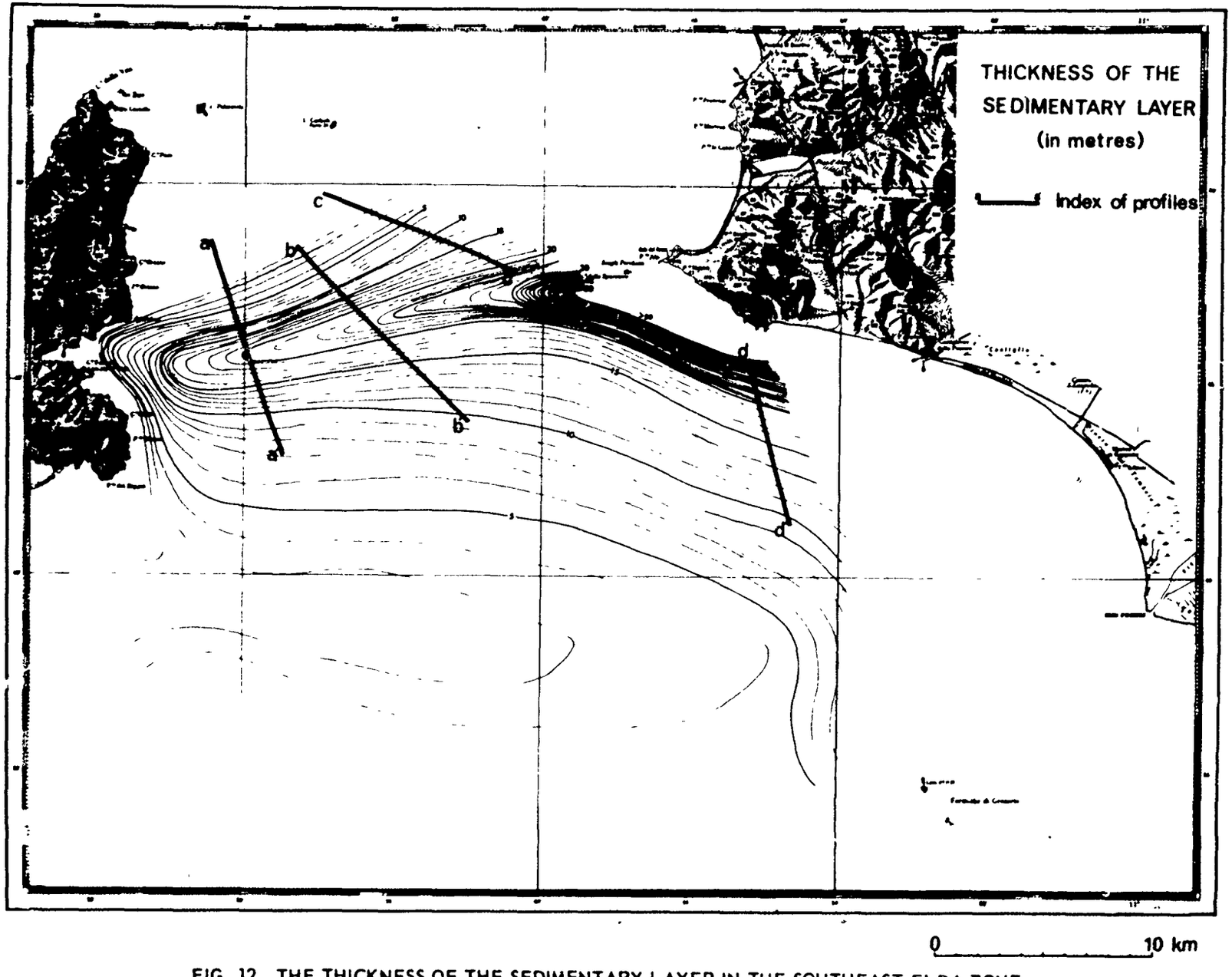

FIG. 12 THE THICKNESS OF THE SEDIMENTARY LAYER IN THE SOUTHEAST ELBA ZONE

FIG. 13 SAMPLE PGR PROFILE FROM THE SOUTHEAST ELBA ZONE

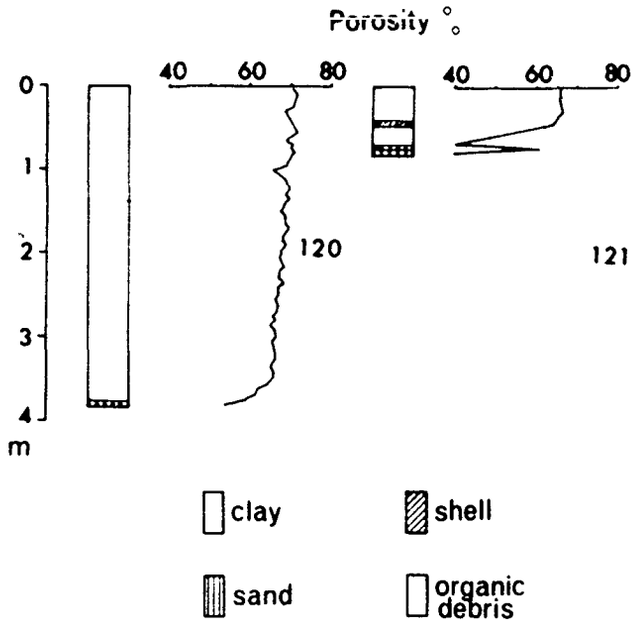

FIG. 14 POROSITIES AND SEDIMENT TYPES OF THE CORES TAKEN IN THE SOUTHEAST ELBA ZONE

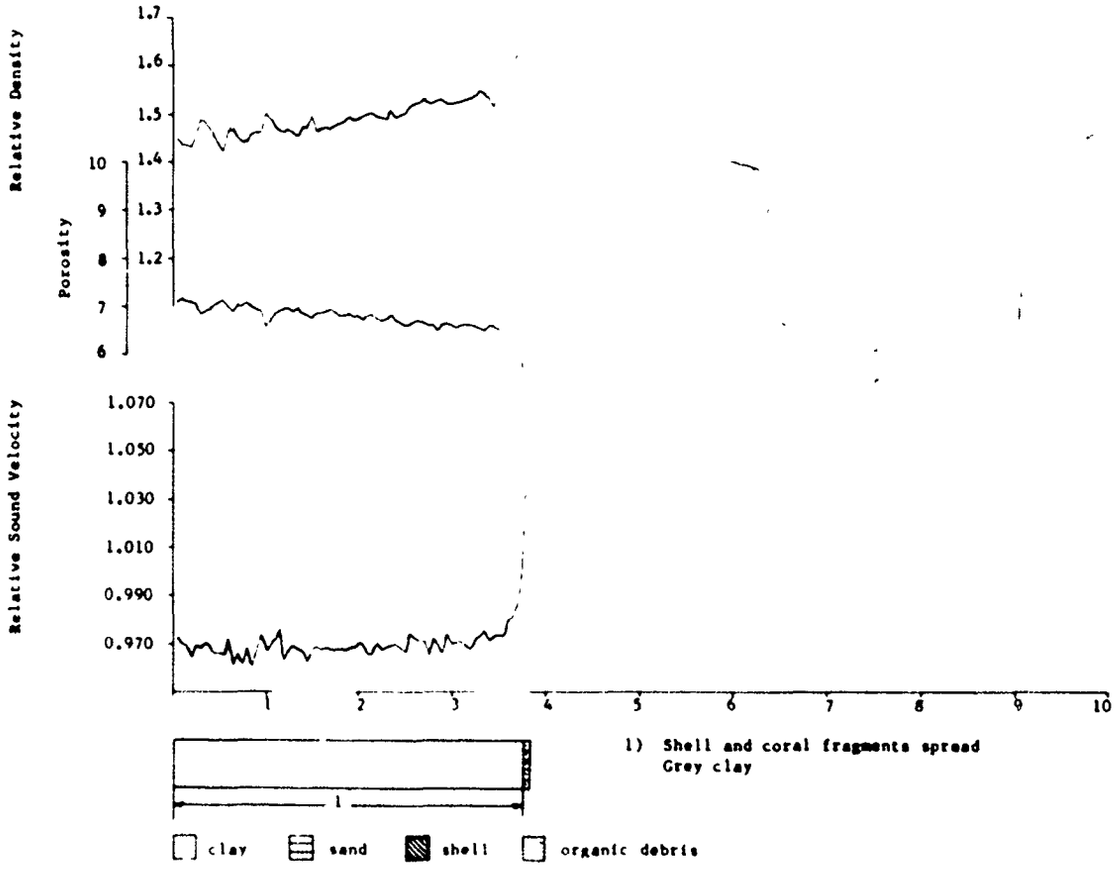

FIG. 15 POROSITY, RELATIVE DENSITY AND RELATIVE SOUND VELOCITY IN CORE 120

FIG. 16 BOTTOM PHOTOGRAPHS FROM THE SOUTHEAST ELBA ZONE

(a) & (b) Examples of photographs from station S1 showing effects of the bottom current

(c) & (d) Characteristic photographs from the zone (burrows are approximately 2 cm diam.)

CONCLUSION

The survey of the environmental characteristics of the zones situated north and south-east of the Island of Elba shows that these zones are suitable for making controlled experiments and have different environmental characteristics that enable acoustic trials to be performed in different conditions.

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2. U.S.N. Hydrographic Office, "Capo Cavallo to Civitavecchia and the Northeast Coast of Corsica", (1:214 880), Chart H.O. 3939, 8th Ed. 1933, Rev. 1961.

3. A. Kermabon, P. Blavier, and U. Cortis, "The SACLANTCEN Sphincter Corer Assembly" SACLANTCEN Technical Report No. 34 (AD 808 766), March 1965, NATO UNCLASSIFIED.

4. C. Gehin, P. Blavier, and B. Matteucci, "Modifications to SACLANTCEN Sphincter Corer", Supplement to SACLANTCEN Technical Report No. 112 (AD 852 429), March 1969 NATO UNCLASSIFIED.

5. A. Kermabon and P. Blavier, "Principles and Methods of Core Analysis at the SACLANT ASW Research Centre", SACLANTCEN Technical Report No. 71 (AD 818 754) August 1967, NATO UNCLASSIFIED.

6. C. Gehin, SACLANTCEN, Private Communication.

7. Istituto Idrografico Italiano, "Tirreno - Italia - dal Canale di Piombino al Promontorio Argentario e Scoglio Africa", (1:100 000), Chart No.5, 3rd Ed.,1968.

[Note: Some references to SACLANTCEN documents quote numbers allocated by the U.S. Defense Documentation Center (AD numbers) and/or the U.S. National Aeronautics and Space Administration (N numbers). Copies of "AD" and "N" documents can be obtained from the U.S. National Technical Information Service, Springfield Va 22151. Copies of "N" documents can also be obtained from ESRO/ELDO Space Documentation Service, 114 av. de Neuilly, 92, Neuilly/s/S, France]